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Chief, Engineering Branch 23 February 1950

Electronic Development Section, [redacted] 25X1

Informal Report on Visit to Squier Signal Laboratory, Fort Monmouth, N.J., on 16 February 1950.

1. [redacted] of the Procurement and Supply Division, and the writer 25X1 visited the Power Resources Branch, Squier Signal Laboratory, Fort Monmouth, N.J., on 16 February 1950, in connection with a proposed development contract with [redacted], Los Angeles, Calif., for a small portable 100 watt engine-driven power unit. 25X1

2. The primary purpose of this visit was to obtain a candid opinion from qualified personnel in the Power Resources Branch as to the feasibility of the above mentioned proposal. A secondary purpose was to pick up any other readily available useful information, on new developments, particularly concerning storage batteries and hand-driven generators.

3. [redacted] Branch Chief of Power Resources Branch, arranged a conference in his office with the interested section chiefs and personnel participating. These included [redacted] and Lt. [redacted] 25X1 25X1 25X1

PART I

After [redacted] had presented [redacted]. informal bid and specification of 10 January 1950, [redacted] suggested that the power requirements alone (100 watts at 115 V.A.C. 400 cycles) be taken as a start and from the knowledge and experience of all present, write a tentative specification for the smallest, lightest, practicable unit possible. 25X1 25X1

After much discussion and some assumptions based on recent Squier Laboratory experiences involving the modification of this Agency's (CIA) Power Unit SSP-12 into a unit designated PU-69, all were agreed that a <u>practicable</u>, <u>dependable</u> unit, with a life expectancy of 2000 hours or better, of the power required could be produced of the following approximate size and weight:

Overall Size	9" x 9" x 9"
Weight	15 lbs.

Of the weight given, 4 pounds would be required for the alternator and the remaining 11 pounds comprising engine, magneto, fuel tank, solenoid governor, cooling blower and baffles, exhaust and intake mufflers, chemical absorption of exhaust gases, steel tubing frame with rubber engine-alternator mounts, but <u>not</u> including provisions for hand cranking in the event of engine failure or exhaustion of fuel supply. [redacted], mechanical engineer, later told this writer, privately 25X1 that while he would not care to commit himself officially, he believed that the total weight could be reduced to 12 pounds.

SECRET

To the technical personnel at Squier, the overall design of [redacted] 25X1 proposal presented a few problems which will be of little consequence in an engine of larger size.

The design of the alternator itself would be more or less cut and dried, offering few problems. A rotating permanent magnet field would be used having Alnico slugs, backed up by a steel ring for the magnetic return circuit, all cast into a one piece unit using an aluminum alloy matrix. The stator would be of the standard type having punched soft iron laminations wound with solid enameled copper wire. The alternator housing would be cast aluminum alloy with possibly integral cast fins to aid in cooling both alternator and engine.

The alternator proper would require no bearings, since its rotor would be mounted directly adjacent to the engine on the outboard side of an engine bearing.

The cooling process would probably present the greatest problem in an engine of this size. Since thermal conductivity is the time rate of transfer of heat by conduction, through unit thickness, across unit area for unit difference of temperature, the reduction of unit thickness and unit area (or mass) of the conducting metal will directly reduce the capacity for heat conduction. This process is given as:

$$Q = \frac{K(t_2 - t_1)aT}{d}$$

Where:
K is given for Q, in Calorie
t_1 and t_2 in degrees C.
a in $cm.^2$
T in seconds
d in cm.

Offsetting this undesirable characteristic is the fact that a smaller engine uses a smaller charge of fuel and therefore requires the transfer of a smaller quantity of heat. On the other hand, the higher normal speed of the smaller engine due to lower inertia of reciprocating and rotating parts swings the balance back again so that the net result is that heat dissipation in a small engine is more of a problem than in the larger size engines. However, this problem is handled in an acceptable manner in model aircraft engines (of which the larger sizes of around .60 cubic inches displacement can be considered fairly representative of the proposed type) by using generous over-sized cooling fins directly exposed to the propeller slip stream.

Next in order of importance would probably be the difficulty of setting and maintaining the correct ratio in the air-fuel mixture. Since a slight change in the carburetor needle valve setting, or a small particle of foreign matter in the fuel, or a small variation in the consistency of the fuel would constitute a much higher percentage of variation in the air-fuel ratio due to the smaller displacement volume, the smaller engine is more critical of adjustment. A plausible solution to this problem could be two semi-fixed carburetor jets, one for starting and the other for running with an automatic vacuum or solenoid controlled change-over. Another solution to this problem could be an automatically controlled metering-pin type of carburetor jet. Either of the two solutions would also compensate to some extent for variations in fuel consistency. The problem of foreign matter in the fuel could be easily solved by using a built-in fuel strainer of chamois or similar material in the fuel tank filler-neck.

A third significant problem is the reduction of engine exhaust noise and the absorption of exhaust gases. However, the technical staff at Squier have developed a small, simple, yet very efficient muffler system which (after this writer witnessed a demonstration of the PU-69) eliminates from 65% to 75% of the exhaust noise. It was generally agreed that further development along the lines of an acoustical-resonance-cancellation system would probably result in a noise reduction of 10% to 15% more.

Chemical absorption of exhaust gases (for un-leaded fuels only) has been practicably achieved by the Catalyst Research Corp. of 6101 Falls Road, Baltimore, Maryland, according to Mr. Ellis of Squier Laboratory.

Hand-cranking provisions in the event of engine failure or exhaustion of fuel supply was rather critically examined, some doubting its feasibility entirely, others more optimistic. All were extremely dubious about the practicalility of using the combination chain and spur gear train cranking mechanism as used in the Signal Corps GN-58 and in this Agency's SSP-11, within the allowable space and weight of the hypothetical unit. However, the writer firmly believes that a planetary type gear train, complete with crank, but not using any chain drive could be built within a weight of approximately 3/4 pound and a size of 5" Dia. x 1 inch thick. Such a gear train would have the larger gears stamped or cut from a high grade of sheet steel, hardened and mounted with oilite bearings, while the small pinions could be of molded nylon for quietness of operation. A gear train of this type would undoubtedly be short-lived as gear trains go, but it would certainly give more than the 200 hours service desired for the unit as a whole.

In connection with the discussion on hand-cranking, [redacted] supplied so 25X1 useful information secured from tests with enlisted personnel on standard Signal Corps units. A maximum of 80-90 watts for a period of from 15 minutes to 1 hour, depending on the individual, can be reasonably expected from a hand-cranked generator.

The hand-crank generator must have a solid tripod support with seat and a speed of 60 revolutions per minute for the crank were considered optimum. The suggestion of a bicycle style seat and foot pedals has advantages in the two facts that the legs are more powerful than the arms and that of gravitational assistance. However, the Signal Corps has never seriously considered this type because of the better target offered by a bicyclist.

The net results of the discussion on the [redacted] proposal were rather 25X1 inconclusive, in the opinion of this writer. To the uninitiated, the "show-me" attitude of the engineer, and his method of analyzing an untried proposition by searching for its faults and exploring every avenue offering any obstacle to that proposition, the discussion would indeed sound discouraging. When this attitude is recognized, and the conservative atmosphere of Squier Laboratory considered. the writer feels that the [redacted] proposal has definite possibilities and sh 25X1 be fully explored.

It should be emphasized, at this point, that the entire tentative specification given above was based almost entirely on Squier Laboratory's past experiences and future possibilities in modification and improvement of their unit PU-69. The PU-69 was evolved almost entirely from the SSP-12, a unit developed for the OSS (predecessor of CIA) during World War II.

A clue to the past performance of the [redacted], on a projec 25X1 very similar to present proposal may be obtained from the attached copy of a trip report submitted by [redacted] 25X1 (mentioned above). It should be noted, however, that the power unit described in the subject trip report was not developed by the [redacted], but by [redacted] 25X1 Santa Monica, Calif., for [redacted] 25X1

Another similar unit was developed for the U.S. Air Forces under contract No. AF28-099-87 by Wedd Laboratories, 2010 Massachusetts Ave., N.W., Washington, D.C. This power unit was rated at 15 watts 45 V.D.C., used standard Air Forces fuel and was contained in a volume of 432 cu. in.

PART II

This part of subject report deals with the aforementioned secondary purpose of the visit to Squier Laboratory.

The only significant new development in storage batteries observed by this writer was a series of 8 - 2 volt cells having clear plastic non-spill cases. These cells, with Signal Corps designations BB-236/U thru BB-243/U inclusive, ranged in size and rating from 1-1/4" x 2" x 3-1/8" @ 2.5 Ampere hours for the BB-236/U to 3" x 4-1/2" x 7" @ 60 Ampere hours for the BB-243/U. It should be quite feasible to mold a single plastic case for 3 of the BB-243/U cells within overall dimensions of 9" x 4-1/2" x 7", giving a 6 volt 60 ampere hour battery of a very convenient size.

It is recommended that this Agency investigate fully the possibilities of the above mentioned storage batteries.

Upon inquiry about hand-driven generators it was learned that, on the same day as this writer's visit to Squier Laboratory, the Burke Electric Co., 1249 West 12th Street, Erie, Penna., had presented specifications for a small, lightweight, hand-driven generator of approximately the same power output as the GN-58. However, upon examination, the proposed generator was, for all practical purposes, the same size and weight of the GN-58. The proposed unit had a marginal advantage of an inch or less and was approximately 1-1/2 pounds lighter.

The PU-69 power unit, already mentioned in Part I, really impressed the writer with its possibilities for this Agency's use. This unit was designed to supply 115 V.D.C. to field teletype units for the Signal Corps. The alternator

Informal Report on Visit to Squier Signal Laboratory, Fort Monmouth, N.J. 16 Feb. 1950
Part II con't.

23 February 1950

output of 120/208 V.A.C. 3 phase 4 wire @ 400 cycles is fed through 3 vacuum tube rectifiers and a simple filter system to give a voltage of 115 D.C. @ 150 watts. Its size is 9" w. x 10-1/2" h. x 14" l. (approx.) and its weight is 19 pounds (approx.). A flattened out version of the same unit with the engine cylinder horizontal instead of vertical is 10-1/2"w. x 8-1/2" h. x 14" l. (approx.

Vapor-lock in the carburetor is a major fault of the SSP-12. After 30 min. or less, depending on ambient temperature, atmospheric pressure, consistency of fuel, etc., its engine will sputter, running very erratically, if at all. This fault, together with other minor faults, has been completely eliminated in the PU-69 version of the SSP-12. Following is a list, necessarily incomplete, of modifications and improvements, over and above the SSP-12, embodied in the PU-69:

1. Elimination of vapor-lock in the carburetor by:

   a. A reduction in mass of the heat transfer path from engine crankcase to carburetor.

   b. An increase in area of attaching flange surface where alternator contacts engine for added heat transfer to alternator.

   c. An increase in mass of alternator housing for added heat dissipation from alternator.

   d. A sheet metal baffle to prevent exhaust cooling air from engine cylinder fins from impinging on alternator housing and to provide added radiation surface.

   e. Redesign of carburetor venturi.

2. Redesign of cylinder and crankcase:

   a. Cylinder head now removable to facilitate carbon cleanout.

   b. Combustion chamber redesigned for higher compression ratio, higher efficiency, and better scavenging.

   c. Redesigned cylinder barrel has steel sleeve liner with shrunk on cast fins and head-crankcase attachment flanges.

   d. Redesigned transfer passage in cylinder barrel has only one change of direction to cut down fluid friction losses of air-fuel mixture.

   e. More efficient transfer and exhaust ports in cylinder liner.

SECRET

f. Better alignment of cylinder and crankshaft by elimination of horizontally split crankcase. Cylinder now attaches to top of crankcase with 4 hold-down bolts. Crankcase shell and one end cast in one piece. Opposite crankcase end attached with concentric mating bolting flange.

3. Redesigned crankshaft, counterweighted, with ball-bearings at each end.

4. Redesigned flapper-valve at crankcase intake.

5. Solenoid governor, actuated by alternator output, replacing wind-vane governor.

6. Redesigned exhaust muffler.

7. Addition of intake muffler, after tests had shown that a great portion of the noise of the unit was coming from intake flapper-valve.

8. Slight modification of alternator rotor for increased efficiency.

Work on the PU-69 is still incomplete and has been temporarily discontinued in favor of other higher priority projects. However, [redacted] has in his drawing files approximately 80% of the completed detailed ESA drawings for the new PU-69. These are complete manufacturing drawings which were finished before suspension of the project. 25X1

The writer was very favorably impressed with both the demonstrations and the discussions centering around the PU-69. All factors indicate that it is a far superior unit to the old SSP-12, and with a reasonable amount of preventive maintenance could be depended on for a reliable source of continuous power.

It is strongly recommended that this Agency investigate fully the possibilities of an improved version of the SSP-12, profiting by the experiences of Squier Laboratory with their PU-69.

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lk Electronic Dev. Section file ✓
cc: [redacted] 25X1
~~XXXXXX~~ Project 2028
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